July 1, 2003

Reply to Comments from July 27, 2001 Review Of NuMI Target Hall

In preparation for the final review of the NuMI Target Hall Re-circulating Air System, we have generated this reply to comments from the previous review of NuMI Target Hall Shielding (held July 27, 2001). Reviewer's comments are in normal type, *replies are in italics*. Only comments dealing with the air system are included here; comments on radiation shielding etc. are being dealt with in other reviews.

- Reference was made to HEPA filters. Perhaps the word "HEPA" should not be used to designate this equipment. This conjures up "nuclear facility" type air systems, which are costly, or impossible, to maintain in accordance with strict ANSI standards applicable to such systems as commonly used to directly protect personnel in other kinds of installations. If one simply calls them "high efficiency" filters without the use of the acronym, this potential compliance issue may well be averted. The other review panel members are welcome to create a better name.

Our documentation now refers to these as "high efficiency filters", as suggested.

- A final check of airflows and their directions will be needed after construction/installation. The airflow pattern is a complicated one and may not be completely predictable given other uncertainties related to cracks, etc.

We have allocated time in the installation schedule to do this test, although we have not worked out a detailed testing plan yet. The task requires the installation of temporary flow/pressure instrumentation; some of the top shielding will have to be removed each time we access this instrumentation. An adjustable damper is planned to allow balancing of the airflow over the top of the target pile (which cools the modules) versus sidewalls plus floor passages.

- The ability to monitor airflow and the desired path is important from the radiological discharge standpoint. Decay time is necessary since a significant part of the labs permit will be eaten up by NuMI operation.

The main monitor of this will be the radiation monitor at the air discharge riser half-way down the decay pipe region, which is the exit path for air from the target hall. If the radiation level becomes unacceptably high, the two options are to better seal the top of the target pile (whose air system is designed to be totally re-circulating, with only leakage into the main air flow) or slow down the airflow from the target hall utility rooms through the target hall and out that riser (in which case installing some local dehumidification in the target hall may be required to reduce corrosion of the crane, air handling equipment, etc).

- Was there any mention of how water leakage into the target hall area on the floor, that could be activated, is either contained or routed?

The primary path for water leaks from the horn or target is downstream along the inside of the air block seal, onto the pit floor under the air return labyrinth, to the "closet" west of the decay pipe concrete pour; the closet acts as a holding area with slow seepage into the under-drain. A second path is taken if leaking horn water penetrates the air block seal thus reaching the target hall floor, or water seeps in through the target pit concrete walls; this path is down the floor outside of the air block seal, then through a drain pipe under the air return labyrinth to the "closet", where a trap prevents a short circuit between the air system supply and return. Please also see "NuMI RAW Systems Containment Plans" at: http://www-numi.fnal.gov/numwork/reviews/july_30.html.

- NuMI needs to figure out how to seal around the transmission line as it goes through the target pile. Does it need to be "sealed" only at the top, and not worry about air going in one direction at the bottom of the TL and in the other direction at the top and thus some leakage? And NuMI needs to make sure that under whatever sealing conditions are determined that the TL is kept sufficiently cooled.

The plan is to have an air seal at the point where the stripline emerges from the R-block concrete cover. The stripline under the concrete cover is in the airflow pattern going upstream over the modules; the stripline through the stripline block to the horn is in a forced air stream due to the pressure differential between supply above the modules and return below the modules.

- Along the same lines, is there a rough estimate as to how much will leak out of the whole target pile to ensure that a limit of 1500-cfm leakage is well above what we expect and thus air activation is not a concern?

The upper limit estimate is 700 cfm leakage out of the target pile (per A. Stefanik). The real leakage number will be at, or most likely below this value. Updated calculations show that running @ 4e13 ppp and 4e20 p/yr and 700 cfm leakage and 650 cfm ventilation rate through the decay tunnel will release ~ 20 Ci/yr at the stack. The ventilation rate around 600-700 cfm is the rate that we are planning for now. The hope is we can run higher, but we will not know until we measure the emissions.

- Is moisture in the pseudo-HEPA filters a problem? An observer suggested that it might be a problem for the filter. Do we expect them to get damp? Where the filters are located the dose rates should be reasonable so that personnel changing them do not incur too much dose. Do we have estimates as to what these dose rates are and how often the filters will need to be accessed?

The system design for the relative humidity at the high efficiency filters around 60%; we expect 70% worst case. So moisture in filters is not expected to be a problem. Filter change will be when filter's clog up as indicated by pressure drop across them – perhaps yearly. Gary Lauten (in the past) said that they change the AP0 air filters every several years (maybe 5 years) and that the main concern when they do it is contamination (and airborne). The activation products are very short-lived and thus by the time they access, the levels are low. AP0 has ALARA and/or RWP procedures for these change outs and *we can use them as a basis for NuMI change-outs. NuMI rates may be 5 times higher or so, so they may need to be changed out once per year. We will need to monitor this when we start running. Residual dose rates don't seem to be an issue. Care will need to be taken for contamination concerns.*

- I thought I heard that the chase air-cooling was based on MARS results and a 10% safety factor. Is there a good basis for the 10%? My concern is that perhaps that is not enough of a safety factor.

The beam power is 400 kW. The MARS model puts nearly 40% of this in the target hall, almost 40% in the decay pipe, 15% in the absorber, a few percent in neutrinos and muons, and a few percent in nuclear binding energy. Because this depends almost entirely on the physics of the proton-graphite interaction in the two interaction lengths of target and a simple geometry of the secondary production angle, the uncertainty is nowhere near as large as for instance the uncertainty in radiation penetrating through the thick shielding, and the estimated error is of order 10%. About 18 kW ends up in the horn and target water-cooling systems, leaving 129 kW (LE beam) or 141 kW (ME beam) for the air system to handle. We have used 158 kW beam power in the specification, giving a 22% (12%) safety factor for LE (ME) beam. Since specific chillers are unlikely to exactly match our specification, there will probably be some small headroom beyond this.

- (From a reviewer that read the documentation but did not attend the review) Target hall ventilation does not appear to be fully designed at this point. It would be prudent for NUMI to review air sample results of pbar vault air UPSTREAM of the HEPA filtered target vault exhaust. My recollection is that fairly significant airborne contamination (above and beyond PET isotopes C11, N13, etc.) exists in the vault upstream of the HEPA filter during beam operation due to activation of airborne dust, rust, etc. This source of contamination could be spread throughout the air cooling system resulting in contamination control requirements for the air cooling system maintenance. In addition, condensate drains in the system could become radioactive due to deposition of same materials on cooling system coils. Recent samples with beam off and beam on have been collected by the BD ES&H Department at pbar vault. If this is found to be a problem, NUMI should strongly consider the use of HEPA filters to remove particulates from the vault return air prior to cooling.

The design started with pbar as a model, so high efficiency (HEPA style) filters were included essentially from the beginning, with the filtration as the first stage when air exits the target pile (before cooling coils and fan). The water condensate from the cooling coils is routed to the underdrain, mixing with the approximately 300 gal/min groundwater inflow that will be discharged on the surface. Please also see "NuMI RAW Systems Containment Plans" at: http://www-numi.fnal.gov/numwork/reviews/july_30.html.

- The Alignment and Metrology Group should be consulted about the wall that is proposed just upstream of the target hall. Placing this wall during the present excavation contract or the follow-on outfitting contract will make their life more difficult. It wasn't fully clear whether this wall was just for air-containment, but if so, it can be a simple concrete masonry unit wall, erected near the end of the installation.

The wall is a six foot thick radiation shield as well as air containment seal. The construction of this wall is being moved to near the end of installation.

- The target hall shielding installation schedule takes the better part of a year, working two shifts. This will require at least three task managers. Identification of these people ought to be a fairly high priority.

In June 2003 two floor managers and one task manager were finally identified. We are beginning to work with them on installation issues.

- The air cooling relies upon control of cracks that can short-circuit the intended path of flow. Once installed, the proposed aluminum sheets will be inaccessible. This whole problem should be given more thought. How do you verify the desired flow once the installation is complete? Are there any intermediate measurements that can be done during the installation phase, while it is still possible to correct things? Is it worth developing a prototype, as was done for seeing how the blocks would stack?

The design allows for a reasonable number of holes in the air block; 10% of the bottom airflow is assumed to leak in the model. The gross airflow will be measured at the end of installation. While we have not developed any intermediate measurements of the seams beyond visual inspection, we plan to discuss the possible use of a vacuum box with soap bubbles with the installation team. We are open to any other suggestions as well about how such intermediate measurements could be done. If we go the vacuum box route, we want to try it out on some prototype aluminum sheets before installation starts.